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By

S. M. Gorodinskiy, L. S. Yes'kova-Soskovets, et al

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В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

PENETRATION OF GASEOUS I^{131} THROUGH HUMAN SKIN

S. M. Gorodinskiy, L. S. Yes'kova-Soskovets, M. I. Rokhlin, Yu. Ya. Sokolov, A. D. Turkin, E. A. Fisnevskaya, V. A. Cherednichenko, S. N. Shatskiy, A. I. Shorokhov

The question of the penetration of radioactive substances through undamaged skin was studied earlier, as a rule, in experiments on animals whose skin structure differs sharply from human skin. Exceptions in this respect are studies of the penetration of radon through human skin which were conducted directly on people by V. I. Baranov and A. P. Novitskaya [1]. The results of these experiments are undoubtedly of interest but they may not be interpreted for iodine vapors since it is necessary to consider the specifics of the physico-chemical nature of the substance on which, as is known, their skin resorption depends to a considerable degree. There is no data in the known literature on investigation of the character and rate of penetration of vapors of a radioactive substance through human skin.

The present work is dedicated to the study of reorption by undamaged human skin of vaporous compounds of I^{131} with isolation of the respiratory organs rrom contaminated air.

The experiments were performed on male volunteers 19-32 years of age. Each subject was subjected to a 3-day clinical examination in the process of which the functional state of the thyroid was determined and blood analyses were performed. In addition the 3-day hospitalization had the purpose of identifying the regimen of the subjects and of standardizing their ration. Persons were allowed to take part in the experiment who did not have deviations in the functional activity of the thyroid, with a normal composition of the peripheral blood and without visible damages of the skin. Some anthropometric data on the subjects is presented in Table 23.

1) Исследуемый	2) Возраст в годах	3) Вес, кг	4) Рост, см	5) Поверхность тела, м²
А.	25	60	164	1,63
Б.	27	75	183	2,03
В.	29	72	182	1,94
Г.	28	74	174	1,92
Д.	27	72	172	1,87
Е.	19	74	177	1,94
Ж.	32	81	178	2,03

Table 23. Anthropometric data or the subjects. KEY: 1) subject; 2)

age in years; 3) weight, kg; 4) height, cm; 5) body surface, m^2.

The body surface area of the subjects was calculated using a Dyubu graph given in the book by N. K. Vitte [2]. The order for conducting the experiment to study resorption of iodine by skin consisted of the following. The subject with unprotected skin was placed in an exposure chamber [3] equipped with a specially developed I^{131}-compound vapor generator. Elementary iodine and the aerosol fraction contained in the source were removed with filters. Thus we studied the resorption by skin only of volatile iodine compounds (predominantly iodites, iodates, oxides of iodine, and so forth). The respiratory organs of the subject were isolated from the entrance of radioactive iodine using a gas helmet into the face portion of which clean air was fed at the rate of 60 liters per minute. The protective helment was connected to the main clean air line using a corrugated rubber hose with a length of 1.5 m. Exhaled air was also removed by hose and exhausted into the space between the protective shells and the exposure chamber.

For ensuring the safety of the subjects the tests were conducted with a relatively low concentration of I^{131} on the order of 10^{-10} Ci/liter with an exposure up to 4 hours. The tests were conducted at a temperature of 27°C; the relative humidity varied from 50 % at

the beginning of the test up to 92 % at the end.

The accumulation of iodine in the thyroid was used to judge its penetration into the organism through the skin. The content of I^{131} in the thyroid was measured using a device consisting of a scintillation sensor of a single-channel amplitude analyzer AADO-1 and a conversion device.

Fifteen tests were performed using the described method; 11 of them in a state of relative quiet of the subject and 4 with an average physical load. Their results are given in Tables 24 and 25 respectively.

Coefficient $K=\frac{A_m}{C}$ is the ratio of the iodine content in the thyroid (A_m in Curies) to the concentration of iodine vapor in the chamber (C in Ci/liter).

1) Исследуемый	2) Концентрация I^{131} в камере, $C \cdot 10^{10}$, кюри/л	3) Содержание I^{131} в щитовидной железе, $A_{щ} \times 10^{10}$, кюри	$K = \frac{A_{щ}}{C}$
А.	3,1	3,1	1,0
Б.	3,5	2,4	0,7
В.	3,5	5,1	1,5
Г.	5,8	9,6	1,7
Д.	8,0	21	2,6
Е.	14	41	2,9
Ж.	40	51	1,3
А.	80	93	1,2
Б.	95	65	0,7
В.	110	89	0,8
Б.	350	303	0,9

Table 24. Resorption by human skin coverings of volatile compounds of I^{131} (in a state of relative quiet). KEY: 1) subject; 2) concentration of I^{131} in the chamber, $C \cdot 10^{10}$, Ci/liter; 3) content of I^{131} in the thyroid, $A_{щ} \cdot 10^{10}$, Ci.

1) № п/п	2) Испытуемый	3) В покое			6) С физической нагрузкой		
		4) концентрация I^{131} в камере, $C \cdot 10^{10}$, кюри/л	5) содержание I^{131} в щитовидной железе, $A_{щ} \cdot 10^{10}$, кюри	K	7) концентрация I^{131} в камере, $C \cdot 10^{10}$, кюри/л	8) содержание I^{131} в щитовидной железе, $A_{щ} \cdot 10^{10}$, кюри	K
1	А.	80	93	1,2	120	170	1,4
2	В.	110	89	0,8	120	130	1,1
3	Е.	14	41	2,9	16	41	2,6
4	Ж.	40	51	1,3	21	42	2,2

Table 25. Relative evaluation of resorption of volatile compounds of I^{131} by human skin at rest and during moderate labor. KEY: 1) No. in sequence; 2) subject; 3) at rest; 4) concentration of I^{131} in the

chamber $C \cdot 10^{10}$, Ci/liter; 5) content of I^{131} in the thyroid, $A_{Ш} \cdot 10^{10}$, Ci; 6) with a physical load; 7) concentration of I^{131} in the chamber, $C \cdot 10^{10}$, Ci/liter; 8) content of I^{131} in the thyroid, $A_{Ш} \cdot 10^{10}$, Ci.

As is evident from Table 24 there is a direct dependence between the content of iodine in the thyroid and its concentration in the chamber.

Coefficient K lies in the limits of 0.7-2.9. Apparently the value of coefficient K is affected by individual peculiarities of the subjects which is evidenced by the scatter of the indices. But in our opinion the obtained experimental dependence between $A_{Ш}$ and C may be applied to all virtually healthy men (in the limits of the conditions under which the tests were performed).

In subjects B and Ye stability was observed in deviation from the mean value of coefficient K. Inasmuch as the conditions of the experiments were sufficiently stable the deviations in the value of coefficients K may be attributed to the functional state of the organism. In subject B no peculiarities were detected during the examination. Subject Ye had a number of functional changes of the neuro-vascular apparatus of the skin (persistent red dermographia,

appearance of spontaneously arising red spots on the skin of the face, neck, and chest and hyperhidrosis; during capillaroscopy a change was detected in the capillary network in the form of an increase in the number of coiled capillaries, basal metabolism +14 %), imparting a vegetative-vascular instability to the picture.

The concentration of I^{131} in the thyroid with its entrance through the skin during a 4-hour exposure may be calculated approximately using the relationship:

$$A_m = 3C,$$

where A_m is the activity of I^{131} in the thyroid gland, Ci; C is the concentration of I^{131} in the air, Ci/liter.

In the given formula for ensuring safety the maximum experimental value of coefficient K, rounded off, was equal to 3.

In order to explain the effect of a physical load on the resorption of iodine supplementary tests were performed as indicated above (Table 25).

Contrary to what was expected the data of the experiments does not make it possible to draw a conclusion concerning an increase in the resorption of iodine with an increase in the physical load. The

obtained results make it possible to consider that in tentative calculations of the quantity of iodine entering the organism through the skin the degree of physical loading (from rest to moderate labor) need not be considered.

As a result of the conducted tests no contamination of the skin by radioactive iodine was noted.

Quite important is the overall evaluation of the quantity of radioactive iodine resorbed by the skin. The maximum permissible quantity of radioactive iodine in the thyroid is $1.4 \cdot 10^{-7}$ Ci [4]. According to the data of our experiments this corresponds to the quantity of iodine resorbed by the skin in 4 hours with a concentration of iodine in the air on the order of 10^{-7} Ci/liter.

Consequently this can be considered the maximum permissible concentration of iodine for volatile compounds of I^{131} in the case of their resorption from the air directly by the skin.

Comparison of the coefficients $K = \frac{A_m}{C}$, obtained during the investigation of the penetration of iodine through the skin (root-mean-square value during a four-hour exposure $K_{cp} = 1.67 \pm 0.75$) and through the respiratory organs (in the latter case according to the data of a work whose results were presented

earlier, K_{cp} = 120 ± 61) [5] shows that the entrance of gaseous iodine through the skin comprises 1-2 % of its entrance through the respiratory organs. Taking into account that the surfaces of the lungs are approximately 100-150 times greater than the body surface it is possible to conclude that the rate of penetration of vaporous compounds of iodine through a unit of surface of lung tissue and through unbroken human skin is approximately the same.

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